# (IS14B-2312) Evaluation of SNPP VIIRS Ocean Color Products on the Louisiana Shelf (PlumeCASE Experiment)

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## I. ABSTRACT

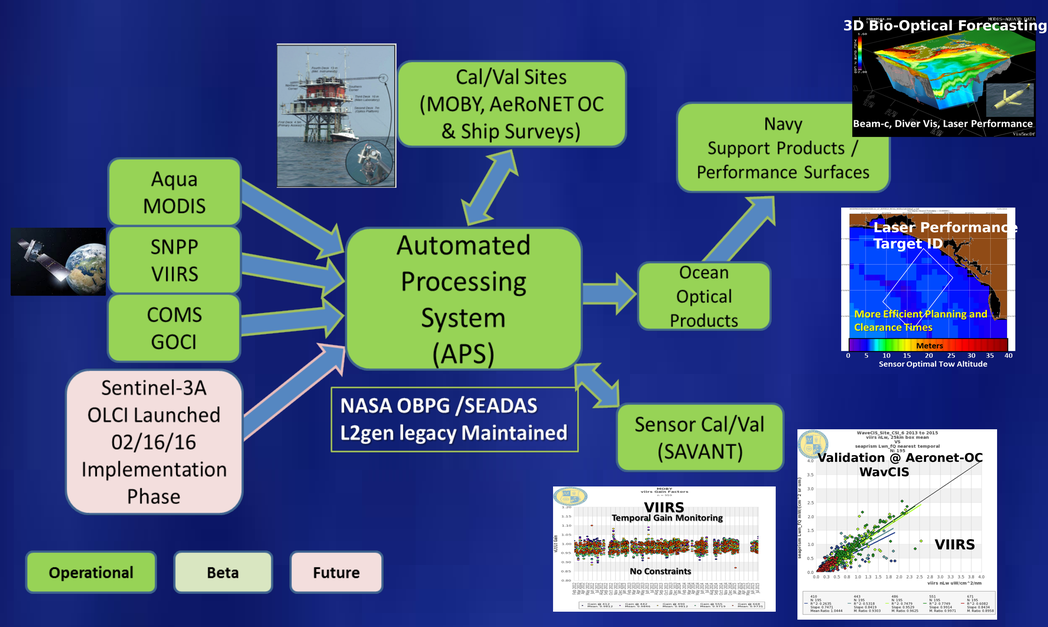

Ocean color products of Inherent Optical Properties (IOPs) and radiances derived from the Suomi National Polar-Orbiting Partnership (SNPP) Visible Infrared Imager Radiometer Suite (VIIRS) using the Naval Research Laboratory's (NRL) Automated Processing System (APS) were statistically evaluated during a two week long exercise, ***Buoyancy Plume Modulation of Coastal Air-Sea Exchange (PlumeCASE)***, in June 2015 over the Louisiana continental shelf. Coastal optical properties in this region are more complex and differ from chlorophyll-dominated waters offshore due to high sediment and CDOM content. NRL has been actively involved with NOAA STAR and the JPSS program during the past 4 years as part of the JPSS/VIIRS ocean color calibration and validation team with the goal of evaluating and reducing uncertainty in SNPP VIIRS ocean color products. VIIRS products will be evaluated using measurements of spectral above and in-water radiances along with supplemental IOPs were collected on station and underway using an above water Analytical Spectral Devices' (ASD) handheld radiometer and profiling and towed (ScanFish) IOP packages. Both IOP packages were equipped with similar instruments including temperature, salinity, total and Color Dissolved Organic Matter (CDOM) absorption and beam attenuation at 9 wavelengths, backscattering at 6 wavelengths, chlorophyll fluorescence, and oxygen. These ocean color properties from SNPP VIIRS will be used to initialize a bio-physical model and for research in the support of the PlumeCASE project objectives. We are using these cruise observations to assess the accuracy of the VIIRS bio-optical algorithms and radiometric calibration. We present VIIRS bio-optical validation and calibration results from the exercise along with temporal and spatial uncertainties and effects from anomalous weather events that occurred during collection for improved SNPP VIIRS ocean color products in support of project goals. The Navy's current assessment of SNPP VIIRS ocean color products indicates that these products are of high quality.


## II. OBJECTIVES

- Evaluate SNPP VIIRS calibrated ocean color products during a two week exercise "PlumeCASE" conducted over the Louisianan Continental Shelf in sediment and CDOM dominated coastal waters.
- Assess the accuracy of the SNPP VIIRS bio-optical algorithms and radiometric calibration using multiple vicarious calibration gain sets (unity = sensor calibration only, blue = MOBY, blended = blue + green)
- Assess SNPP VIIRS ocean color temporal and spatial uncertainties in coastal waters during major storm induced mixing event.

## III. Satellite Processing

Satellite processing was performed using the Naval Research Laboratory's Automated Processing System (APS). This system is built on NASA's legacy software l2gen with modifications to include Navy specific mission support products. APS satellite processing spans multiple satellites including SeaWiFS, MERIS, MODIS, SNPP VIIRS, GOCI and OLCI (near future).



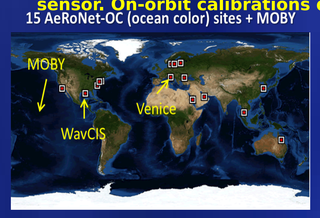

## IV. Calibration and Validation Activity

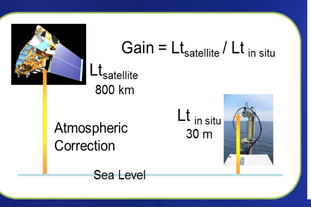
**See Poster #ME54B-0920 Friday (Bowers, etal.)**

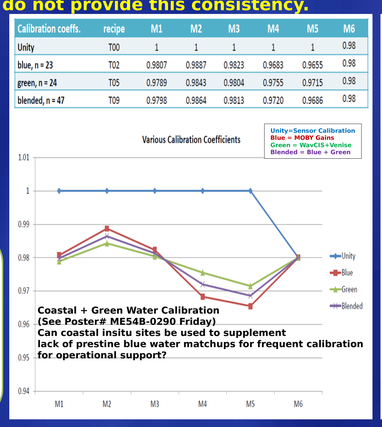
NRL is actively involved with NOAA STAR and the JPSS program during past 5 years as part of the JPSS/VIIRS ocean color calibration and validation team with the goal of investigating and improving cal/val techniques and evaluating and reducing uncertainty in SNPP VIIRS ocean color products. NRL frequently evaluates sensor performance and performs vicarious calibrations (2x per year) based on NASA protocols for multiple satellite sensors *for operational use. These calibrations using same insitu source ensures continuity and inter-sensor accuracy of ocean color and Navy operational products*. Mid-stream changes in sensor calibration (Level-0 to Level-1) and changes in performance (drift, degradation, etc.) affects cal/val.

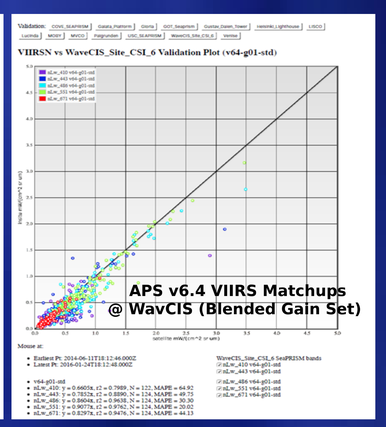
Continuity refers to maintaining an ocean color asset in space for multiple ocean color sensors (CZCS -> SeaWiFS -> MODIS -> MERIS -> VIIRS -> OLCI). Channels are similar on each, but not exactly the same.

Consistency refers to calibrating sensors on different platforms, so that the values between sensors are similar. A product generated from one sensor must agree with a product generated from another sensor. On-orbit calibrations do not provide this consistency.



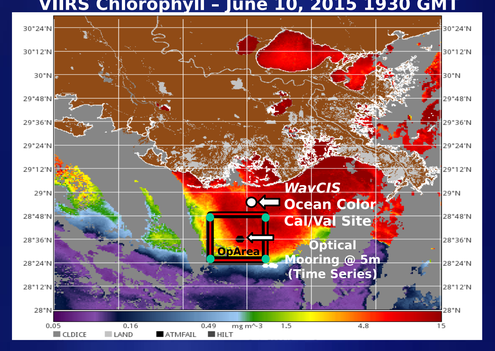




## V. PlumeCASE Exercise (June 08 – 20, 2015) - VIIRS Ocean Color Validation

**Project Objective: Physical/Optical Consequences of River Plumes over the Shelf (Air-Sea Exchange)**

VIIRS Chlorophyll – June 10, 2015 1930 GMT




4 Mooring Sites - ADCPs, Wave/Tide Gauges, High Res Temp, DO (mini Temp/DO data-loggers)

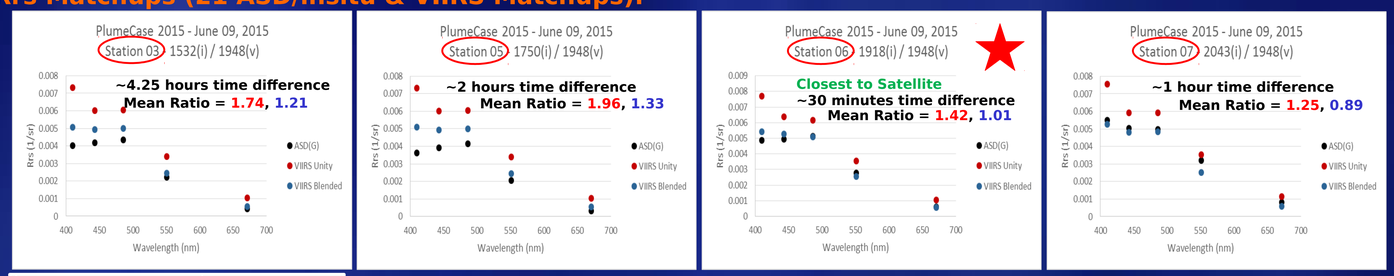
Optical Mooring w/ AC-9 & CTD located near center of operational box

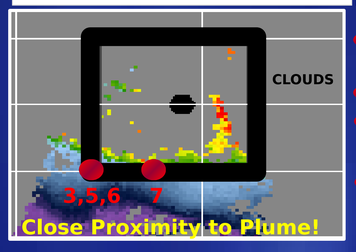
Towed Platform (ScanFish): CTD, AC-9, BB3, Fluor and Irradiance Sensors profiles

ASD measrements: 35 total stations (station + underway) producing 21 valid

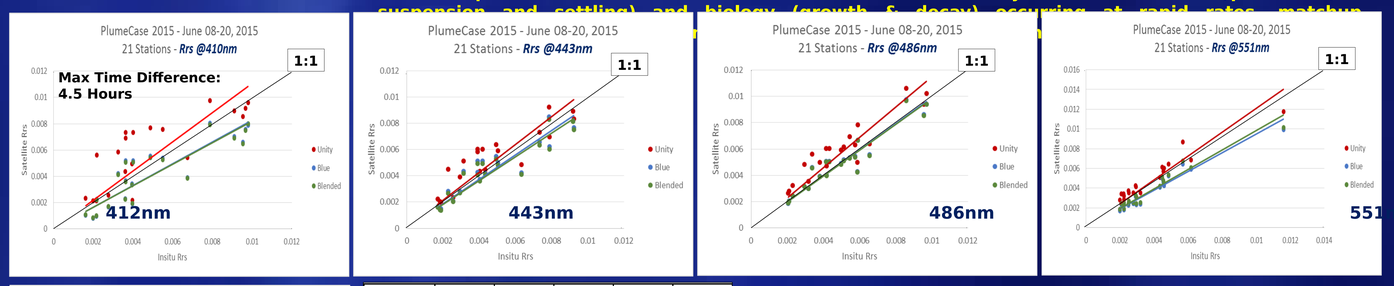
- VIIRS Chlorophyll image (blue water gains) shows high biology/sediment/CDOM rich coastal plume/waters at beginning of exercise (June 10th)
- Mixing of the water column occurred due to atmospheric trough producing high winds (June 12th) and tropical storm "Bill" (June 15th) passing through producing 10-15 foot seas decreasing optical conditions and reducing stratification in op-area.
- Cruise Region progressed to early cruise state (June 20th) with the return of surface buoyancy plume and stratified subsurface conditions.
- VIIRS imagery was processed using unity and blue, green and blended vicarious calibration gains.

### Rrs Matchups (21 ASD/insitu & VIIRS Matchups):




- Plots above show spectral matchups between insitu/ASD (black) and VIIRS Rrs for 4 stations on the same day spanning 5.25 hours for unity / sensor calibration only (red) and blended blue+green (blue) gain sets
- Note the improvement statistically (mean ratio) in the matchups that are closest in time (station 6/7).
- Results show that matchups in coastal regions are better with narrow time constraints and with vicarious calibration yielding improved spectral shape and lower uncertainties. Sensor calibration alone is not adequate.
- With complexities in coastal waters due to advection and dynamics of sediment/particles (re-suspension and settling) and biology (growth & decay) occurring at rapid rates, matchup



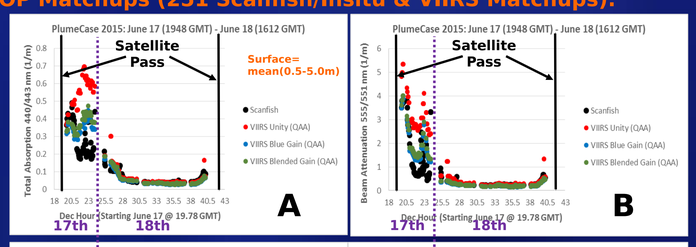

| AvgError(%) | 410 | 443 | 486 | 551 | 671 |
|---|---|---|---|---|---|
| Unity | 41.1490 | 25.6950 | 26.5407 | 33.0813 | 125.3907 |
| Blue | 27.5525 | 15.8164 | 10.0497 | 10.4041 | 26.0425 |
| Blend | 26.9136 | 16.0198 | 10.1462 | 10.5672 | 33.2509 |

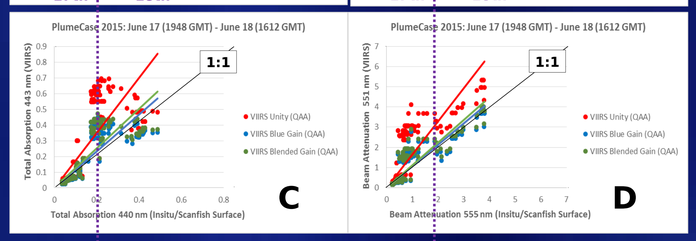
| AvgRatio | 410 | 443 | 486 | 551 | 671 |
|---|---|---|---|---|---|
| Unity | 1.3199 | 1.2010 | 1.2461 | 1.3308 | 2.2539 |
| Blue | 0.8463 | 0.9851 | 1.0175 | 0.9732 | 1.1499 |
| Blend | 0.8382 | 0.9502 | 1.0101 | 1.0176 | 1.2593 |

| Slope(b=0) | 410 | 443 | 486 | 551 | 671 |
|---|---|---|---|---|---|
| Unity | 1.1065 | 1.0611 | 1.1490 | 1.2092 | 1.4401 |
| Blue | 0.8285 | 0.9310 | 0.9928 | 0.9505 | 1.0154 |
| Blend | 0.8195 | 0.9053 | 0.9853 | 0.9832 | 1.0606 |

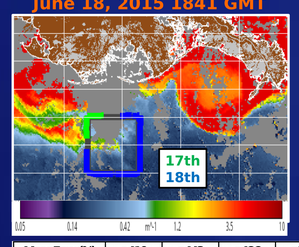
- Scatter plots show matchups for each channel separately between VIIRS (unity/sensor cal only, blue & blue/green blended gain sets) and insitu/ASD Rrs measurements for 21 valid stations spanning 18 days.
- Statistics (table) show: 1) sensor-cal/unity gain (red) has highest uncertainty, 2) standard blue water gains (blue) derived from MOBY matchups overall provide lowest uncertainty and best performance and 3) supplementing the blue water vicarious calibration with green water matchups (blended) can provide adequate calibration for real-time operational support and getting new sensors into operations more quickly (4 months vs 12 months. Desired # of highly constrained matchups for vicarious calibration is > 30 (NASA protocol).

### IOP Matchups (251 Scanfish/Insitu & VIIRS Matchups):




VIIRS w/ Scanfish Tracks
June 18, 2015 1841 GMT




Temporal matchups and scatter plots of insitu IOPs vs VIIRS for total absorption @443nm (A,C) and beam attenuation @ 551nm (B,D) along with statistics (table). In addition to rrs matchups, IOP matchup plots and stats show that using a blue and blue/green/blended vicarious gain sets in coastal waters produce similar results and an improvement over sensor calibration (unity/red) only. Note data collected in between the 2 satellite passes on 17th and 18th

| MeanError(%) | a410 | a443 | a486 | a551 | a671 | c410 | c443 | c486 | c551 | c671 |
|---|---|---|---|---|---|---|---|---|---|---|
| Unity | 92.5196 | 59.2871 | 54.2582 | 39.4608 | 3.3050 | 122.5978 | 109.2021 | 98.9710 | 79.3591 | 45.9633 |
| Blue | 64.4659 | 32.3735 | 29.7131 | 24.2381 | 4.2773 | 54.4904 | 39.0876 | 35.3464 | 38.4489 | 21.7829 |
| Blend | 67.8332 | 35.4666 | 31.7869 | 24.8536 | 4.1136 | 61.3319 | 45.5991 | 39.3502 | 39.6120 | 23.2572 |

| MeanRatio | a410 | a443 | a486 | a551 | a671 | c410 | c443 | c486 | c551 | c671 |
|---|---|---|---|---|---|---|---|---|---|---|
| Unity | 1.7619 | 1.5285 | 1.4854 | 1.2779 | 0.9777 | 2.2200 | 2.0844 | 1.9777 | 1.7660 | 1.4174 |
| Blue | 1.4291 | 1.0694 | 1.0394 | 1.0052 | 0.9632 | 1.5063 | 1.3227 | 1.2110 | 1.0753 | 1.0377 |
| Blend | 1.5006 | 1.1611 | 1.1151 | 1.0360 | 0.9640 | 1.5855 | 1.4080 | 1.2937 | 1.1481 | 1.0783 |

| Slope | a410 | a443 | a486 | a551 | a671 | c410 | c443 | c486 | c551 | c671 |
|---|---|---|---|---|---|---|---|---|---|---|
| Unity | 2.4700 | 1.7300 | 1.4700 | 1.3000 | 0.9600 | 1.7900 | 1.6900 | 1.6700 | 1.6400 | 1.5000 |
| Blue | 1.8700 | 1.1400 | 1.0100 | 0.9800 | 0.9900 | 1.2600 | 1.1200 | 1.0800 | 1.0600 | 1.0500 |
| Blend | 1.9500 | 1.2300 | 1.0800 | 1.0200 | 0.9500 | 1.3200 | 1.1800 | 1.1400 | 1.1100 | 1.1000 |

## VI. SUMMARY

- Vicariously calibrated SNPP VIIRS performs very well for both surface radiances (Rrs) and Inherent Optical Properties (IOPs) based on matchups during PlumeCase June 2015 exercise in coastal waters on Louisiana Shelf.
- Rrs and IOP matchup in coastal waters are better with smaller time window and with vicarious calibration (blue or blended/blue/green gain sets) yielding improved spectral shape and lower uncertainties over all spectral channels. Note: Matchup uncertainties can increase with increasing time constraints (>30 minutes) in coastal waters especially if river/coastal plumes exist.
- Sensor calibration (unity gain set = 1.0) alone in coastal waters is not adequate and has highest Rrs matchup uncertainty (25 - 125% error w/ mean ratio for all wavelengths = 1.15), blue water gains overall provide lowest uncertainty (10-28% error w/ mean ratio for all wavelengths = 0.94) and using a blended blue/coastal gain set can provide adequate calibration for operational support (10-33% error w/ mean ratio for all wavelengths 0.95).
- Sensor calibration (unity gain set = 1.0) has highest IOP matchup uncertainty over all wavelengths (3.3-93%Absorption/46-122% Beam-c error range; mean ratio = 1.49 Absorption/1.89 Beam-c), blue water gains overall provide lowest spectrally mean uncertainty (4.3-64% Absorption/21-54% Beam-c error w/ mean ratio for all wavelengths = 1.09 Absorption/1.22 Beam-c). Blue and blended (blue/green) IOP uncertainties are very similar : blended blue/green gain set can provide adequate calibration for operational support (4.2-64% Absorption/23-61% Beam-c error w/ mean ratio for all wavelengths 1.15 Absorption/1.27 Beam-c).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